

# Cook/Chill Foodservice Systems: Temperature Histories of a Cooked Ground Beef Product During the Chilling Process<sup>1</sup>

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## ABSTRACT

Temperature histories during the chilling process under actual operating conditions in a school cook/chill foodservice system and in laboratory experiments show it was not possible to chill cooked entrees to 45 F (7 C) or below within 4 h when entrees were stored in walk-in refrigerators. Consideration should be given to equipment designed for the chilling process before converting to cook/chill foodservice systems.

Rising costs and the shortage of a reliable workforce have contributed to development of the cook/chill concept in school and hospital foodservice systems. In a cook/chill foodservice the entree is cooked 1 to 3 days in advance of service and chilled in bulk to refrigerator temperature. On the day of service, the chilled entree is portioned into individual servings in a central assembly unit, stored in refrigerated holding equipment, and transported to the point of service where convection or microwave ovens are used to reheat the entree to desired serving temperature.

During the chilling process in a cook/chill system the entree should be cooled rapidly to 45 F (7 C) or below to retard bacterial growth. Longree (3) recommends that the internal temperatures of food should reach 45 F (7 C) within 4 h and should not remain between 60-120 F (16-49 C) for more than 2 h. Only a few researchers have reported temperature histories of cooked entrees during the chilling process in cook/chill foodservice systems (1,2,4). These investigators recorded temperature histories at only one location in the food product; temperature histories are often reported as incidental to the major aim of the research.

Questions have been raised about the capability of refrigeration equipment currently used in schools and hospitals to chill entrees to 45 F (7 C) or less within a 4-h

time period. This study was conducted to observe the length of time required for a cooked ground beef product to cool to 45 F (7 C) when chilled according to procedures which may be used in a school cook/chill foodservice system.

## MATERIALS AND METHODS

The study consisted of two parts: I, temperature data collected under actual operating conditions in a school cook/chill foodservice system; and II, temperature data collected in a laboratory under conditions simulating procedures used in the school foodservice system.

### Study I

Temperature data were collected in a school cook/chill foodservice system where about 3800 Type A lunches were processed daily. Preparation and chilling procedures for entrees were observed on 9 days during a 4-week period. On each day of the field study, 10 pans of food were selected to be monitored for temperature change during the chilling process; five pans from each of two racks (24-10 × 18 × 4½-inch pans/rack). Temperature at the geometric center of the food mass (10 × 18 × 3 inch) was recorded at hourly intervals from the time of initial chilled storage in the walk-in refrigerator until the temperature at the geometric center of the food mass was approximately 45 F (7 C). Temperature of the food mass was measured by a thermometer (Taylor Bi-Therm Pocket Dial, 0-200 F., Sybron Corp., Arden, NC). Ambient temperature in the refrigerator was read from an integral thermometer attached to the refrigeration unit.

### Study II

Procedures used to prepare and chill entrees in the school cook/chill foodservice system were simulated in a laboratory under controlled conditions. A review of the 5-week cycle menu used in the school foodservice system showed that a ground beef product appeared most often as the entree. A recipe for barbeque ground beef was modified to provide the entree for the experimental study. Procedures for preparation and chilling of the ground beef product were standardized to minimize variation among three trials of the experiment.

*Preparation.* Forty-eight hours before preparation, 25 lb (11.3 kg) of ground beef were removed from frozen storage (-22 F; -30 C) to thaw in a walk-in refrigerator. On the day of preparation, the ground beef was browned for 45 min in a 5-gal steam-jacketed kettle (Groen, Model TDC/2-20, Elk Grove Village, Ill.). Prepared mustard (1.13 lb; 0.5 kg) and ketchup (2.0 lb; 0.9 kg) were added and the mixture was simmered an additional 30 min to a temperature in excess of 175 F (79 C). The product was poured into a 12 × 20 × 4-inch counter pan to a depth of 2 inches. The product in the pan remained at room temperature (80 F; 27 C) approximately 5 min until the temperature at the geometric

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center the food mass (12 × 20 × 2 inch) reaches 170 F (77 C) as recorded by a potentiometer (Honeywell, Model 153x64-P8H-II-III-42, Minneapolis, MN). The pan of ground beef product was transferred immediately to the walk-in refrigerator adjacent to the preparation area.

**Chilling.** The pan of ground beef product was placed in the refrigerator on a shelf opposite the refrigerator fan. Five Type T, copper-constantan, thermocouples were positioned in the product to measure temperature at five layers in the center of the product in the pan. Thermocouples, 1 to 5, monitored the temperature of the product at locations 1.8 inches (4.5 cm); 1.4 inches (3.5 cm); 1.0 inch (2.5 cm); 0.6 inch (1.5 cm); 0.2 inch (0.5 cm) from the top surface of the product in the pan, respectively. Thermocouples were fastened to a plastic guide stick to prevent movement of the thermocouples in the food mass during the chilling process. Ambient temperature in the refrigerator was monitored by two thermocouples positioned 6 inches above the pan of product in the refrigerator.

**RESULTS AND DISCUSSION**

*Study I*

Data in Table 1 show that the initial temperature of several entrees was 100 F (38 C) or less. It was not a practice of the cooks in the foodservice operation to allow entrees to cool at room temperature before being transferred to the walk-in refrigerator. In most instances, prepared ingredients were removed from refrigerated storage and canned ingredients were removed from the storeroom to be combined with browned ground beef in a steam-jacketed kettle. In other instances, cold ingredients were combined in the unheated steam-jacketed kettle and portioned into 10 × 18 × 4-1/2-inch counter pans.

Results of the time-temperature measurements during the chilling process (Table 1) show that the time required for the average temperature at the geometric center of the food mass to reach 45 F (7 C) ranged from 7.0 to 11.0 h. The average temperature of the entree did not reach 45 F (7 C) within 4 h on any of the 9 days of the field study. Temperatures recorded in the walk-in refrigerator varied during the field study (Table 1).

*Study II*

Mean temperatures of the product and the refrigerator during 24-h chilled storage for three trials are shown in Fig. 1. The average temperature of the refrigerator varied slightly among the three trials; 38 ± 4 F (3 ± 2 C) for Trial I and 36 ± 4 F (2 ± 2 C) for Trials II and III, with an average of 37 ± 5 F (3 ± 3 C) for three trials.

Data in Fig. 1 show that the thermocouples located near the bottom of the food mass consistently recorded higher temperatures than thermocouples at other locations in the product. Four and one-half hours were required for temperatures near the surface of the product (thermocouple #5) to reach 45 F (7 C) or less which was 30 min longer than the time recommended for cooling (3). At the end of 6 h mean temperatures at all locations in the center of the product were ≤ 45 F (7 C). Findings in Fig. 1 show that it was not possible to chill the ground beef product through the 120-60 F (49-16 C) temperature range within 2 h, nor was it possible to chill the ground

TABLE 1. Time-temperature relationships and load in refrigerator during chilling of nine entrees under actual operating conditions in a school cook/chill foodservice system

Entree	Temperature range	Cooling <sup>a</sup> time (h)	Refrigerator temperature	Load (No. of pans) <sup>b</sup>
	(F/C)		(F/C)	
Turkey barbecue	93-45	7.0	39 ± 5	72
	34-7		4 ± 3	
Lasagna	90-46	7.0	39 ± 5	72 <sup>c</sup>
	32-8		4 ± 3	
Macaroni and cheese	68-46	8.0	42 ± 8	48
	20-8		6 ± 4	
Chili II	94-45	8.0	44 ± 11	96
	34-7		7 ± 6	
Chili I	84-48	9.0	42 ± 6	96
	29-9		6 ± 3	
Barbecue ground beef	126-46	9.5	38 ± 6	48
	52-8		3 ± 3	
Hot beef sandwich	162-48	10.0	46 ± 13	72
	72-9		8 ± 7	
Spanish hamburger casserole	100-46	10.5	39 ± 8	72
	38-8		4 ± 4	
Beef stew	125-48	11.0	44 ± 11	70
	52-9		7 ± 6	

<sup>a</sup>Time required for the temperature at the geometric center of the entree to pass through the temperature range. Average of 10 pans of the entree.

<sup>b</sup>10 × 18 × 3-inch food mass in an 10 × 18 × 4-1/2-inch pan.

<sup>c</sup>72 (23-1/4 × 15-1/2 × 2 inch) pans.

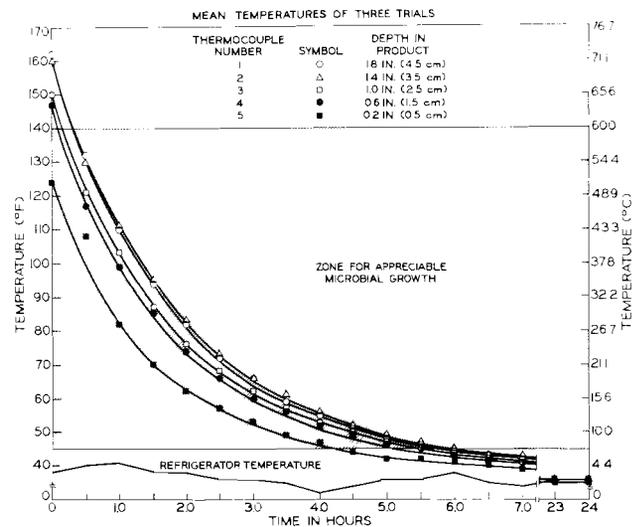


Figure 1. Effect of time on temperature of ground beef during chilling process: Mean temperatures recorded at five depths in the center of product during three trials. Thermocouples #1 and #5 show mean temperatures from only two trials.

beef to 45 F (7 C) or less in 4 h in a typical walk-in refrigerator (37 ± 5 F; 3 ± 3 C).

Factors influencing cooling of the ground beef product include the temperature in the entree before cooling, dimensions of the food mass, product load in the refrigerator, and temperature in the refrigerator. The

internal temperatures of the ground beef product, recorded at the beginning of chilled storage, ranged from 124-161 F (51-72 C) and averaged 149 F (65 C) for the five depths in the center of the product. Although changing the dimensions of the food mass, i.e., depth of the product in the pan, may speed cooling of the product, decreasing depth of the product in the pan would increase the number of pans to be chilled. Depending upon facilities available and number of pans, storage problems could occur when large quantities of food were being chilled.

Product load in the refrigerator during this experiment was one 12 × 20 × 4-inch counter pan, the standard size pan routinely used in foodservice operations. Under normal operating conditions, the number of pans of food to be chilled would be considerably greater than one. A large number of pans of hot food placed in the refrigerator can increase the temperature in the refrigerator and slow the rate of cooling of food products placed in the refrigerator to cool. Although refrigerator temperature could be lower than  $37 \pm 5$  F ( $3 \pm 3$  C), it is doubtful that a reduction in refrigerator temperature alone could achieve a temperature of 45 F (7 C) in food within the recommended 4-h period, especially with an

increased product load. When refrigerator temperature is too low, freezing may occur near the surface of the product and may damage the quality of food.

Special equipment is needed to rapidly chill hot entrees to 45 F (7 C) or less without adversely affecting food quality. Such equipment should be evaluated under actual operating conditions in a cook/chill foodservice system before it is advertised as available for the foodservice industry.

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